Observations of the Satellites of Mars. By Professor A. Hall.

(Communicated by Rear-Admiral John Rodgers, U. S. N., Superintendent U. S. Naval Observatory.)

PHOBOS.

Date.	Wash. M. T. (h m)	p	No. Comp.	t.	Wash. M. T. (h m)	s	No. Comp.	Wt.	Remarks.
1879 Oct. 12	13 3·5	52·12	4	3	13 9·5	24·24	2	3	Extremely faint, sky murky.
15	13 53·5	234·53	2	1	⋯ ⋯	⋯	⋯	⋯	Very bright.
16	12 32·0	235·71	4	4	12 37·0	25·46	2	4	
16	12 59·0	231·45	4	4	13 5·0	24·42	2	4	Faint.
16	13 33·5	225·61	3	3	13 38·5	17·87	2	3	
19	13 14·2	54·36	4	2	13 20·7	25·92	2	2	Very faint.
19	14 4·7	46·61	4	2	14 11·2	19·49	2	2	
20	12 10·3	55·35	4	2	12 15·3	25·54	2	2	Faint, sky murky.
20	12 41·3	50·38	4	2	12 47·8	23·77	2	2	
23	12 47·5	234·54	4	2	12 56·0	25·83	2	2	
24	11 54·1	234·97	4	2	11 59·6	26·22	2	2	Faint.
25	11 1·6	231·58	4	3	11 6·1	26·21	2	3	
26	9 52·2	233·81	4	3	9 57·2	26·72	2	3	Visible with Mars in field.
26	10 26·7	228·16	4	3	10 32·2	22·92	2	3	
2	13 56·1	54·74	4	2	14 3·1	27·09	2	2	Faint, moonlight.
3	12 54·1	53·88	4	4	12 58·6	26·34	2	4	
3	13 15·1	49·77	4	4	13 18·6	25·55	2	4	
3	13 44·1	44·76	4	4	13 49·1	21·49	2	4	
4	11 57·2	52·13	4	4	12 1·7	26·52	2	3	

Date.	Wash. M. T. h	m	p	No. Comp.	Wt.	Wash. M. T. h	m	s	No. Comp.	Wt.	Remarks.
Nov. 4	12	52·7	41·48	4	4	12	58·7	18·03	2	4	
6	10	15·8	48·33	4	2	10	21·3	24·13	2	2	
6	13	48·3	232·37	4	3	13	53·8	26·52	2	3	
7	8	57·8	51·00	4	2	9	3·8	25·83	2	2	
7	12	56·3	229·11	4	3	13	1·3	25·67	2	3	
12	11	24·6	50·80	4	2	11	30·1	25·21	2	2	Windy.
13	10	4·1	54·05	4	3	10	8·1	25·89	2	3	
14	9	2·1	53·19	4	3	9	6·6	25·93	2	3	Clouds.
14	12	19·3	238·93	4	2	12	27·1	23·91	2	2	
14	13	6·6	231·28	4	3	13	13·1	25·86	2	3	
15	11	48·4	233·42	4	4	11	53·4	26·43	2	4	Visible with Mars in field.
16	11	0·8	232·13	4	4	11	5·3	25·91	2	4	
20	10	38·5	51·29	4	3	10	44·0	24·76	2	3	
21	9	25·5	53·72	4	3	9	29·5	25·15	2	3	
21	13	21·5	232·26	4	3	13	27·0	25·17	2	3	No illumination
22	8	5·6	56·95	4	3	8	10·6	24·37	2	3	
23	11	27·7	229·21	4	3	11	32·7	24·57	2	3	
24	6	41·3	47·46	4	2	6	46·3	23·52	2	2	
24	10	11·3	231·84	4	4	10	16·8	24·85	2	4	
30	7	59·7	48·06	4	3	8	5·2	23·07	2	3	
Dec. 1	6	59·8	48·84	4	3	7	4·8	22·86	2	3	Faint.
1	10	46·8	228·91	4	3	10	50·8	22·94	2	3	Faint.

Deimos.

Date.	Wash. M. T. (h m)	p (°)	No. Comp.	Wt.	Wash. M. T. (h m)	("")	No. Comp.	Wt.	Remarks.
1879 Oct. 13	12 10·8	57·11	4	2	12 17·3	59·47	2	2	Very faint, haze.
13	13 37·8	53·85	4	2	13 47·3	63·45	2	2	Very faint, haze.
15	10 36·0	235·78	4	2	10 41·5	63·93	2	2	Faint.
15	11 52·5	232·26	4	2	12 0·0	62·81	2	2	Visible with Mars in field.
15	13 26·5	228·66	4	2	13 32·5	56·90	2	2	Faint, haze.
16	12 45·0	249·30	4	4	12 52·0	37·55	2	4	
16	13 19·0	246·03	4	3	13 25·3	42·93	2	3	Very faint, haze.
20	11 5·8	236·74	4	3	11 9·3	63·29	2	3	
20	12 54·3	232·76	4	3	12 59·3	64·74	2	3	
23	13 6·5	60·17	4	2	13 13·5	54·61	2	2	
24	11 40·6	219·64	4	2	11 45·6	40·08	2	2	Faint.
25	10 52·6	240·46	4	3	10 57·6	57·60	2	3	
25	13 1·6	234·13	4	3	13 7·1	66·81	2	3	
29	10 9·8	229·59	4	1	10 18·8	62·83	2	1	Extremely faint.
Nov. 2	14 28·1	66·60	4	2	14 42·4	51·48	2	2	Faint, clouds and moonlight.
3	10 22·6	230·48	4	4	10 27·1	65·98	2	4	Just visible with Mars in field.
3	13 3·1	220·62	4	4	13 8·1	49·33	2	4	
3	14 1·1	215·59	4	4	14 7·6	39·20	2	4	

Date.	Wash. M.T. (h m)	p	No. Comp.	Wt.	Wash. M.T. (h m)	s	No. Comp.	Wt.	Remarks.
Nov. 4	11 43.2	246.44	4	3	11 49.7	48.86	2	3	
4	13 4.7	240.69	4	4	13 11.2	59.68	2	4	
6	10 1.8	62.76	4	2	10 6.8	55.54	2	2	
6	12 4.8	55.65	4	3	12 10.3	65.27	2	3	
6	13 34.3	51.56	4	3	13 39.8	65.88	2	3	
7	9 10.8	210.32	4	2	9 15.8	36.65	2	2	Faint.
10	9 17.5	48.55	4	2	9 22.0	63.13	2	2	Clock fails and acts badly.
12	7 54.9	223.29	4	2	8 12.1	55.12	2	2	Clouds, clouds.
12	10 15.6	209.29	4	2	... ...	...	...	...	Very faint.
13	7 42.6	246.92	4	2	7 50.6	49.22	2	2	
13	10 13.1	236.62	4	4	10 18.1	64.65	2	4	
14	12 36.6	258.08	4	2	12 55.3	38.14	2	2	Clouds.
15	9 19.9	50.82	4	3	9 25.9	65.30	2	3	Visible with Mars in field.
15	11 35.9	43.35	4	4	11 41.9	55.96	2	4	
16	11 13.3	68.73	4	4	11 18.3	46.93	2	4	
18	11 42.4	235.21	4	2	... ...	...	...	...	Faint, cloudy.
20	8 6.0	58.70	4	2	8 12.0	60.42	2	2	Windy.
20	10 29.0	50.59	4	3	10 33.5	63.36	2	3	
21	13 10.5	64.59	4	3	13 15.5	52.67	2	3	No illumination, lamp fails.

Date	Wash. M. T. (h m)	°	No. Comp.	Wt.	Wash. M. T. (h m)	s	No. Comp.	Wt.	Remarks.
Nov. 22	7 52·1	230·43	4	4	7 57·6	62·71	2	4	
23	11 7·7	241·70	4	2	11 22·2	57·17	2	2	Clouds.
24	6 51·8	44·67	4	3	6 55·8	56·92	2	3	
29	6 49·1	48·29	4	3	6 55·1	58·50	2	3	Faint.
30	9 53·2	61·23	4	3	9 58·2	53·70	2	3	
Dec. 1	7 11·8	214·59	4	3	7 17·8	41·59	2	3	Very faint.
12	11 47·8	232·56	4	3	11 55·8	51·46	1	3	Faint.
16	7 37·2	228·55	4	2	7 44·2	50·37	1	2	Very faint.
18	5 55·2	44·77	4	3	5 59·7	47·68	2	3	Faint, but distinctly seen.

The outer satellite was found immediately on the first night it was looked for, October 10, and very near the position computed from my elements. The sky soon became cloudy, and no observation could be made on that night. On the next clear night, October 12, I had the pleasure of finding the inner satellite, also near the computed position. This satellite was decidedly brighter than I expected to see it. After this day the sky became covered with a thin haze, which made the observations of the satellites difficult, but on October 16, the sky cleared up and the satellites came out remarkably bright. On this day Professor Holden, who was observing the inner satellites of Saturn, made the following note:—

"Phobos easily seen; it is much brighter than I have ever seen Mimas at elongation, and I should say almost, if not quite, as bright as Enceladus is at elongation."

The observations were made in the following manner. In order to avoid sliding the eye-piece, as was done in 1877, a piece of coloured glass, covering one half the field of view, was inserted in the forward end of the eye-piece, near the micrometer wires. It might be better to silver one half the forward lens of the eye-piece, but an attempt to do this did not give a good result. In making the observations, the planet was placed behind the coloured glass, through which the wire could be seen, and, both objects being kept near the centre of the field, the angle of position and the distance were measured by bisecting the disk of the planet and the satellite. In this way the observations were made in much less time than by sliding the eye-piece. Generally, as will be seen, each observation depends on four settings of the position circle, and four measures of the single distance, the No. of Comp. for the distance being divided by 2, to make them conform to those of 1877. The effect of the coloured glass was to give a slightly different adjustment of the focus for the two parts of the field, but this adjustment was always made for the satellite, or the free part of the field. The eye-piece used was one furnished by the makers of the telescope, and gives a magnifying power of about 400. This eye-piece is not quite achromatic, showing some colour near the edges of the field; and in order to compare the measures made with it and the coloured glass, with those made with the achromatic eye-piece used in 1877, and which has no coloured glass, I measured the distance of Mars from several stars which it passed, with both eye-pieces, the measures being so arranged that the motion of the planet was nearly eliminated for the mean of the times. These measures show no constant difference between the two eye-pieces, and I think the measures of last year will be found as accurate as those of 1877.

The observations have been reduced in the same manner as those of 1877, and the preceding values of p and s are corrected for differential refraction and the figure of the disk.

Before comparing the observations with the elements the perturbations of these satellites produced by the Sun were computed,

and for the secular perturbations, I found values agreeing with
those given by Mr. Marth (*Astr. Nach.* No. 2280). If we sup-
pose the perturbations to be really effective, the probability that
the satellites at the time of their discovery should move in planes
coincident with the equator of the planet is very slight. There
can be but little doubt that the view taken by Professor Adams,
(*Monthly Notices*, November 1879), and also by M. Tisserand,
(*Comptes Rendus de l'Académie des Sciences*, Dec. 8, 1879), will
prove to be correct: viz. that these satellites are held nearly in
the plane of the equator by the slightly elliptical figure of the
planet. For this reason I have neglected the secular perturbations.
The coefficients of some of the periodical terms depending on the
position of the satellite in its orbit may amount to nearly three
minutes of arc; but these terms have very short periods and their
effect on the observations is nearly insensible. I have therefore,
for the present, neglected these also.

In the case of Phobos, the Besselian auxiliary quantities f, F,
g, G, depending on the position of its orbit-plane, were computed
from the elements found from the Washington observations of
1877. A preliminary calculation having shown that the periodic
time of this satellite is nearly

$$T = 7^{\rm h}\ 39^{\rm m}\ 13^{\rm s}\!\cdot\!996,$$

the values of u were computed for this value of the period. The
observations of Deimos were compared directly with the elements.

The following tables give the results of these comparisons.
The residuals Δp have been converted into errors of longitude Δu,
and for these errors I assume that the equation of condition is of
the form

$$x + by + n = 0,$$

in which $x = \Delta u$ for the epoch Nov. 5.0 Greenwich m.t.; y is
the variation of Δu in ten days, and n is the value of the error in
longitude resulting from the observation. Strictly, the weights
for these equations should depend on the factor for converting
the residuals Δp into errors of longitude. This factor varies
from 2·9 to 6·2 in the case of Phobos; and from 1·1 to 5·6 for
Deimos. But on the other hand, when this factor becomes small
the observations were more difficult, and in the present work I
have given the weight unity to all the observations, except that
of Phobos on Oct. 15, which depends on two comparisons only,
made when the satellite was hardly visible; and to this I have
given a weight of one-fourth.

The quantities Δp and Δs are given in the sense, Calculated
minus Observed place. In the last column are given the resi-
duals found by substituting the resulting values of x and y in the
equations of condition.

PHOBOS.

		Δp	Δs	Equations of Condition.	Residuals.
Oct.	12	$+ 1°31$	$+ 0''54$	$x - 2·32y - 8°09 = 0$	$- 7°93$
	15	$- 2·18$	...	$\frac{1}{2}x - 1·01y + 6·52 = 0$	$+ 6·71$
	16	$- 0·88$	$- 0·18$	$x - 1·93y + 5·14 = 0$	$+ 5·59$
	16	$- 0·20$	$+ 0·07$	$x - 1·92y + 1·13 = 0$	$+ 1·59$
	16	$0·00$	$+ 1·23$	$x - 1·92y + 0·00 = 0$	$+ 0·46$
	19	$+ 0·31$	$- 0·20$	$x - 1·62y - 1·75 = 0$	$- 1·06$
	19	$+ 0·78$	$+ 1·89$	$x - 1·62y - 3·25 = 0$	$- 2·56$
	20	$- 0·41$	$+ 0·18$	$x - 1·53y + 2·27 = 0$	$+ 3·02$
	20	$+ 0·23$	$+ 0·89$	$x - 1·53y - 1·21 = 0$	$- 0·46$
	23	$+ 1·04$	$+ 0·17$	$x - 1·23y - 5·45 = 0$	$- 4·47$
	24	$- 0·77$	$+ 0·07$	$x - 1·13y + 4·11 = 0$	$+ 5·17$
	25	$+ 1·12$	$+ 0·16$	$x - 1·03y - 5·87 = 0$	$- 4·74$
	26	$- 0·13$	$- 0·22$	$x - 0·94y + 0·68 = 0$	$+ 1·88$
	26	$- 0·01$	$+ 0·94$	$x - 0·93y + 0·04 = 0$	$+ 1·25$
Nov.	2	$- 0·27$	$- 0·32$	$x - 0·22y + 1·25 = 0$	$+ 2·99$
	3	$+ 0·44$	$+ 0·37$	$x - 0·13y - 2·01 = 0$	$- 0·20$
	3	$+ 1·00$	$+ 0·94$	$x - 0·12y - 4·38 = 0$	$- 2·56$
	3	$+ 0·54$	$+ 1·09$	$x - 0·12y - 1·79 = 0$	$+ 0·03$
	4	$+ 1·17$	$+ 0·31$	$x - 0·03y - 5·35 = 0$	$- 3·46$
	4	$+ 0·32$	$+ 1·92$	$x - 0·02y - 0·85 = 0$	$+ 1·04$
	6	$+ 1·35$	$+ 1·81$	$x + 0·16y - 5·71 = 0$	$- 3·68$
	6	$- 0·37$	$+ 0·20$	$x + 0·18y + 1·64 = 0$	$+ 3·69$
	7	$+ 0·68$	$+ 0·79$	$x + 0·26y - 2·96 = 0$	$- 0·85$
	7	$+ 0·96$	$+ 0·49$	$x + 0·28y - 4·07 = 0$	$- 1·95$
	12	$+ 0·87$	$+ 1·09$	$x + 0·77y - 3·55 = 0$	$- 1·06$
	13	$+ 0·60$	$+ 0·23$	$x + 0·86y - 2·37 = 0$	$+ 0·19$
	14	$+ 1·33$	$+ 0·19$	$x + 0·96y - 5·20 = 0$	$- 2·57$
	14	$+ 3·19$	$- 0·88$	$x + 0·97y - 9·18 = 0$	$- 6·54$
	14	$+ 0·27$	$+ 0·29$	$x + 0·98y - 1·07 = 0$	$+ 1·58$
	15	$+ 1·18$	$- 0·44$	$x + 1·07y - 4·55 = 0$	$- 1·83$
	16	$- 0·58$	$+ 0·11$	$x + 1·17y + 2·26 = 0$	$+ 5·05$
	20	$+ 0·43$	$+ 0·72$	$x + 1·56y - 1·60 = 0$	$+ 1·49$
	21	$+ 0·18$	$+ 0·14$	$x + 1·66y - 0·66 = 0$	$+ 2·50$
	21	$+ 0·67$	$+ 0·31$	$x + 1·68y - 2·48 = 0$	$+ 0·70$
	22	$+ 0·92$	$- 0·29$	$x + 1·75y - 3·00 = 0$	$+ 0·23$
	23	$+ 0·84$	$+ 0·15$	$x + 1·87y - 3·00 = 0$	$+ 0·32$
	24	$+ 1·27$	$+ 0·70$	$x + 1·95y - 4·39 = 0$	$- 1·01$
	24	$+ 1·18$	$+ 0·04$	$x + 1·96y - 4·23 = 0$	$- 0·84$

	Δp	Δs	Equations of Condition.	Residuals.
Nov. 30	$+ \overset{\circ}{1}{\cdot}76$	$+ \overset{''}{0}{\cdot}36$	$x + 2{\cdot}55y - \overset{\circ}{6}{\cdot}53 = 0$	$- \overset{\circ}{2}{\cdot}69$
Dec. 1	$+ 0{\cdot}38$	$+ 0{\cdot}25$	$x + 2{\cdot}65y - 1{\cdot}27 = 0$	$+ 2{\cdot}64$
1	$+ 0{\cdot}92$	$+ 0{\cdot}19$	$x + 2{\cdot}67y - 3{\cdot}08 = 0$	$+ 0{\cdot}85$

DEIMOS.

	Δp	Δs	Equations of Condition.	Residuals.
Oct. 13	$+ \overset{\circ}{0}{\cdot}24$	$+ \overset{''}{0}{\cdot}48$	$x - 2{\cdot}23y - \overset{\circ}{1}{\cdot}24 = 0$	$- \overset{\circ}{2}{\cdot}23$
13	$+ 0{\cdot}34$	$- 0{\cdot}08$	$x - 2{\cdot}22y - 1{\cdot}92 = 0$	$- 2{\cdot}91$
15	$- 0{\cdot}65$	$- 1{\cdot}04$	$x - 2{\cdot}04y + 3{\cdot}58 = 0$	$+ 2{\cdot}58$
15	$+ 0{\cdot}12$	$- 0{\cdot}82$	$x - 2{\cdot}03y - 0{\cdot}63 = 0$	$- 1{\cdot}63$
15	$- 0{\cdot}07$	$- 1{\cdot}57$	$x - 2{\cdot}02y + 0{\cdot}30 = 0$	$- 0{\cdot}70$
16	$- 0{\cdot}73$	$+ 1{\cdot}35$	$x - 1{\cdot}93y + 1{\cdot}46 = 0$	$+ 0{\cdot}46$
16	$- 0{\cdot}49$	$+ 1{\cdot}24$	$x - 1{\cdot}92y + 1{\cdot}28 = 0$	$+ 0{\cdot}28$
20	$- 0{\cdot}26$	$- 0{\cdot}06$	$x - 1{\cdot}53y + 1{\cdot}31 = 0$	$+ 0{\cdot}30$
20	$- 0{\cdot}42$	$- 0{\cdot}83$	$x - 1{\cdot}52y + 2{\cdot}16 = 0$	$+ 1{\cdot}15$
23	$+ 1{\cdot}30$	$+ 1{\cdot}52$	$x - 1{\cdot}22y - 4{\cdot}71 = 0$	$- 5{\cdot}74$
24	$- 1{\cdot}91$	$- 1{\cdot}87$	$x - 1{\cdot}13y + 3{\cdot}30 = 0$	$+ 2{\cdot}27$
25	$- 0{\cdot}01$	$+ 1{\cdot}03$	$x - 1{\cdot}03y + 0{\cdot}04 = 0$	$- 1{\cdot}00$
25	$+ 0{\cdot}22$	$- 0{\cdot}84$	$x - 1{\cdot}02y - 1{\cdot}09 = 0$	$- 2{\cdot}13$
29	$- 1{\cdot}19$	$- 2{\cdot}59$	$x - 0{\cdot}64y + 4{\cdot}68 = 0$	$+ 3{\cdot}63$
Nov. 2	$- 1{\cdot}12$	$+ 0{\cdot}88$	$x - 0{\cdot}22y + 2{\cdot}87 = 0$	$+ 1{\cdot}80$
3	$- 0{\cdot}37$	$- 1{\cdot}11$	$x - 0{\cdot}14y + 1{\cdot}53 = 0$	$+ 0{\cdot}46$
3	$- 0{\cdot}35$	$+ 0{\cdot}23$	$x - 0{\cdot}12y + 0{\cdot}82 = 0$	$- 0{\cdot}25$
3	$- 1{\cdot}91$	$- 1{\cdot}98$	$x - 0{\cdot}12y + 3{\cdot}13 = 0$	$+ 2{\cdot}06$
4	$- 0{\cdot}42$	$+ 1{\cdot}18$	$x - 0{\cdot}03y + 0{\cdot}99 = 0$	$- 0{\cdot}09$
4	$- 0{\cdot}35$	$+ 0{\cdot}82$	$x - 0{\cdot}03y + 1{\cdot}21 = 0$	$+ 0{\cdot}13$
6	$- 0{\cdot}65$	$+ 1{\cdot}55$	$x + 0{\cdot}16y + 1{\cdot}55 = 0$	$+ 0{\cdot}46$
6	$- 0{\cdot}28$	$+ 1{\cdot}07$	$x + 0{\cdot}17y + 0{\cdot}91 = 0$	$- 0{\cdot}18$
6	$- 0{\cdot}43$	$+ 0{\cdot}22$	$x + 0{\cdot}18y - 1{\cdot}77 = 0$	$+ 0{\cdot}68$
7	$- 1{\cdot}16$	$- 2{\cdot}90$	$x + 0{\cdot}26y + 1{\cdot}27 = 0$	$+ 0{\cdot}18$
10	$- 0{\cdot}62$	$- 0{\cdot}18$	$x + 0{\cdot}56y + 3{\cdot}42 = 0$	$+ 2{\cdot}31$
12	$- 0{\cdot}20$	$- 1{\cdot}70$	$x + 0{\cdot}75y + 0{\cdot}54 = 0$	$- 0{\cdot}57$
12	$- 2{\cdot}15$	$\ldots$	$x + 0{\cdot}76y + 2{\cdot}27 = 0$	$+ 1{\cdot}16$
13	$- 0{\cdot}57$	$+ 1{\cdot}69$	$x + 0{\cdot}85y + 1{\cdot}28 = 0$	$+ 0{\cdot}17$
13	$- 0{\cdot}32$	$- 0{\cdot}02$	$x + 0{\cdot}86y + 1{\cdot}18 = 0$	$+ 0{\cdot}06$
14	$- 1{\cdot}65$	$+ 1{\cdot}90$	$x + 0{\cdot}97y + 2{\cdot}16 = 0$	$+ 1{\cdot}04$
15	$+ 0{\cdot}03$	$- 0{\cdot}56$	$x + 1{\cdot}06y - 0{\cdot}11 = 0$	$- 1{\cdot}23$
15	$- 0{\cdot}80$	$- 1{\cdot}83$	$x + 1{\cdot}07y + 2{\cdot}10 = 0$	$+ 0{\cdot}97$
16	$- 1{\cdot}15$	$+ 1{\cdot}79$	$x + 1{\cdot}17y + 2{\cdot}37 = 0$	$+ 1{\cdot}24$

	Δp	Δs	Equations of Condition.	Residuals.
Nov. 18	$-0°29$	$...$	$x + 1·37y + 1·04 = 0$	$-0°10$
20	$-0·23$	$+0·31$	$x + 1·56y + 0·79 = 0$	$-0·35$
20	$-0·22$	$-0·33$	$x + 1·57y + 1·15 = 0$	$0·00$
21	$-1·12$	$+1·34$	$x + 1·68y + 2·86 = 0$	$+1·71$
22	$-0·11$	$-0·48$	$x + 1·75y + 0·38 = 0$	$-0·77$
23	$-0·15$	$-0·29$	$x + 1·87y - 0·42 = 0$	$-1·58$
24	$-0·26$	$-1·26$	$x + 1·95y + 0·72 = 0$	$-0·44$
29	$+0·18$	$-0·50$	$x + 2·45y - 0·57 = 0$	$-1·75$
30	$-0·75$	$+1·04$	$x + 2·56y + 2·11 = 0$	$+0·90$
Dec. 1	$-1·09$	$+0·81$	$x + 2·65y + 1·81 = 0$	$+0·61$
12	$-0·46$	$+1·15$	$x + 3·77y + 1·45 = 0$	$+0·22$
16	$-0·02$	$-1·11$	$x + 4·15y + 0·06 = 0$	$-1·22$
18	$+0·26$	$-1·85$	$x + 4·35y - 0·71 = 0$	$-1·98$

The normal equations for Phobos are

$$+40·25x + 6·16y - 81·60 = 0,$$
$$+ 6·16x + 82·83y - 74·28 = 0;$$

the solution gives

$$x = \Delta u = + 1°·912 \pm 0°·3429.$$

The probable error of a single value of Δu is $\pm 2°·163$. We have therefore the value of the periodic time of this satellite

$$T = 7^h \ 39^m \ 13·9376^s \pm 0·01382^s.$$

The longitude for the epoch Nov. 5.0, 1879, is

$$u = 68°·87 \pm 0°·343.$$

The normal equations for Deimos are

$$+46·00x + 17·24y + 50·45 = 0,$$
$$+ 17·24x + 137·20y + 24·74 = 0;$$

the solution gives

$$x = \Delta u = - 1°·080 \pm 0°·1671,$$

and the probable error for a single value of Δu is $\pm 1°·106$. Hence the periodic time of this satellite is

$$T = 30^h \ 17^m \ 54·377^s \pm 0·0949^s;$$

and the longitude for the epoch is

$$u = 3\overset{\circ}{2}2\cdot 91 \pm \overset{\circ}{0}\cdot 167.$$

After December 1 the weather, which had been unusually favourable, became bad, and the image of the planet was so blazing and unsteady that no further observations of Phobos were made. Although the brighter of the satellites, Phobos is always so near the limb of the planet that it is much more affected by a poor image of Mars. This satellite was seen last on December 16. On December 18, Deimos could be observed with tolerable accuracy, and this satellite was seen last, with certainty, on December 26, but it was too faint to observe. When all the observations of these satellites are published, I hope to undertake their discussion and the determination of new elements.

Although these satellites were brighter than I expected to see them in the Opposition of 1879, still the formula

$$\text{Brightness} = \frac{C}{r^2 \Delta^2}$$

will probably represent the brightness for different Oppositions with a fair approximation to the truth. Assuming this brightness to be unity on October 1, 1877, the following table gives the brightness for several dates in 1879 and in 1881 :—

Date.	Brightness.
1879, Sept. 21	0·491
Nov. 5	0·730
Dec. 12	0·423
18	0·371
26	0·335
1881, Dec. 9	0·389
31	0·384

These satellites will therefore be visible for several weeks in December 1881, in the Washington 26-inch Refractor, the declination of the planet being + 26°. Unfortunately this Opposition occurs at a season of the year when the weather is generally very unfavourable for making observations at the northern observatories. If such a powerful telescope as Mr. Commons' reflector could be mounted at Malta or Madeira, perhaps a series of observations of these satellites might be secured in the Opposition of 1881. Such a position would also be favourable for observing the satellites of Saturn, whose oppositions will occur in the autumn, and which is coming into a good position for observations of its Ring and faint satellites.

As the Washington observations of Hyperion, the faint satellite of Saturn, have been referred to, I will say that I observed this satellite on 32 nights in 1878, and on 28 nights in 1879.

The Washington observations of the satellites of Saturn need revision and a complete reduction, and as I have not found time to do this, their publication is delayed; but anyone who needs my observations of Hyperion can have them.

> 1880, *January* 27.
>   *Washington, U.S.*

Observations of Mimas and of an Occultation of Rhea in 1879 with the 26-inch Equatoreal at Washington. By Prof. Edward S. Holden, U.S.N.

(*Communicated by Rear-Admiral John Rodgers, U.S.N., Superintendent U.S. Naval Observatory.*)

1879.   *Sept.* 29.

W. m. t. p (estimated) 270°.   Mag. Power 600 A ; Wt. 4.

$10^h\ 27^m$. $p = 270°\cdot2$ (4).
$10^h\ 59^m$. $s = 28''\cdot62$ (4) ; satellite very faint ; moonlight.

1879.   *Sept.* 30.

p (estimated) 285°.   Mag. Power 600 A ; Wt. 4.

$10^h\ 27^m$. $(s) = 24''\cdot14$ (4) distance measured in the line of major axis of the ring; nearly full moon about 10° distant.

1879.   *Sept.* 30.
Mag. Power 800 A.

$10^h\ 50^m$. I do not think it is up yet, to *s. p.* the end of the ring, but it is very nearly up.
$10^h\ 54^m$. I suspect I have made a mistake and that it was a little past at $10^h\ 50^m$; it seems to be past now. The seeing is growing quite unsteady (Wt. 2) and *Mimas* is v. F.
$10^h\ 59^m$. *Mimas* not seen after this with eye-pieces 400 A and 600 A.

1879.   *Sept.* 30.
Mag. Power 400 A ; Wt. 2.

[Occultation (disappearance) of *Rhea*.

$11^h\ \ 3^m$. *Rhea* is still visible, but very close to the limb of ball.
$11^h\ 10^m$. I no longer see any dark space between the satellite and the ball, but the planet's limb is unsteady.
$11^h\ 13^m$. Satellite seen less than half the time.
$11^h\ 15^m$. Satellite nearly smooth with the limb. Seeing much better (Wt. 4).